Collaborative Quiz #2 SOLNS
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ECE 345/ ME 380
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[11] 1. No zeros, 2 poles.

$\Delta(s) = s^2 + Ks + 2500$

poles at $s = \frac{-K \pm \sqrt{K^2 - 4 \cdot 2500}}{2}$

2. Phase variable form:

$A = \begin{bmatrix} 0 & 1 \\ -2500 & -K \end{bmatrix}$, $B = \begin{bmatrix} 0 \\ 1 \end{bmatrix}$ $C = [2500 \quad 0]$, $D = 0$.

3. $s^2 + Ks + 2500 = s^2 + 2\zeta\omega_n s + \omega_n^2$

$\Rightarrow K = 2\zeta\omega_n$ $\qquad 2500 = \omega_n^2$

$\frac{K}{2\omega_n} = \zeta$ $\longleftarrow$ $50 = \omega_n$

$\Rightarrow \zeta = \frac{K}{100}$

4. $T_s = \frac{4}{\zeta\omega_n} = \frac{4}{(K/2)} = \frac{8}{K}$

$T_p = \frac{\pi}{\omega_n\sqrt{1-\zeta^2}} = \frac{\pi}{50\sqrt{1-\left(\frac{K}{100}\right)^2}} = \frac{2\pi}{\sqrt{100^2 - K^2}}$

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1. $0 = |sI - A|$

$$= \begin{vmatrix} s & -1 \\ 2500 & s+k \end{vmatrix}$$

$= s^2 + ks + 2500 \longrightarrow$ same as $\Delta(s)$.

$\therefore$ (a), (b), (c) are true.

2. (a), (b), (d) satisfy settling time

(b), (d) satisfy overshoot.

(c),

$\therefore$ (b) + (d).

3. See next page.

4. (a) + (c) are correct.

5. With $K = 50\sqrt{2}$, $\zeta = \frac{50\sqrt{2}}{100} = \frac{1}{\sqrt{2}}$ which generates an overshoot just less than 5%, and $T_s = \frac{8}{50\sqrt{2}} \simeq 0.11$ which meets both primary specifications.

With $K = 40$, $\zeta = 0.4$ will not satisfy overshoot criterion + $T_s = \frac{8}{40} = 0.2$ will not satisfy settling time criterion.

Hence $K = 50\sqrt{2}$ is the better choice.

ECE 345 / ME 380: Introduction to Control Systems
Collaborative Quiz #2 Grading Sheet

Dr. Oishi

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This quiz is open-note and open-book. Computational tools (Matlab, calculators) are allowed. No partial credit will be awarded. For each of the questions, clearly write the correct answer.

In-Class Questions

1. _____
2. _____
3.